HRSD

Cleaning wastewater every day for a better Bay.

Sustainable Water Recycling

Aquifer Replenishment System (ARS)

EVGWAC – Workgroup 1

September 17, 2015

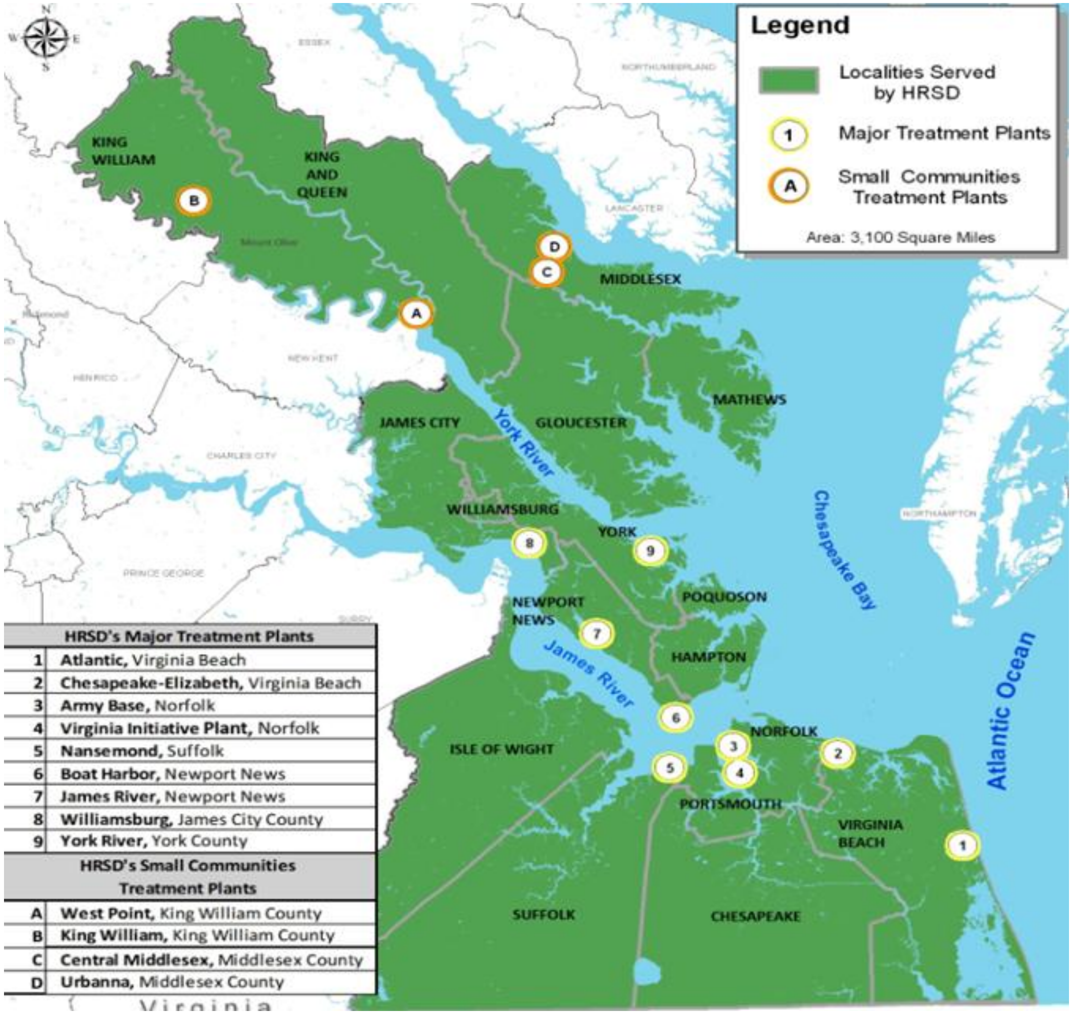
Ted Henifin, P.E.

Jay Bernas, P.E.

Daniel Holloway, P.G. (CH2M)

Agenda

- Drivers
- Study Purpose
- Groundwater
- Advanced Water Treatment
- Conceptual Cost Estimates
- Conclusion & Next Steps
- Questions



- Political subdivision
- 17 cities and counties
- 1.7 million people
- Permitted capacity of 249 MGD
- 500 miles of pipelines
- 112 pump stations
- 462,000 service connections
- FY16-FY25 Capital Program $1.4B

Drivers for water recycling

- Stricter wastewater regulations
- Land subsidence
- Groundwater depletion
- Saltwater contamination of the groundwater

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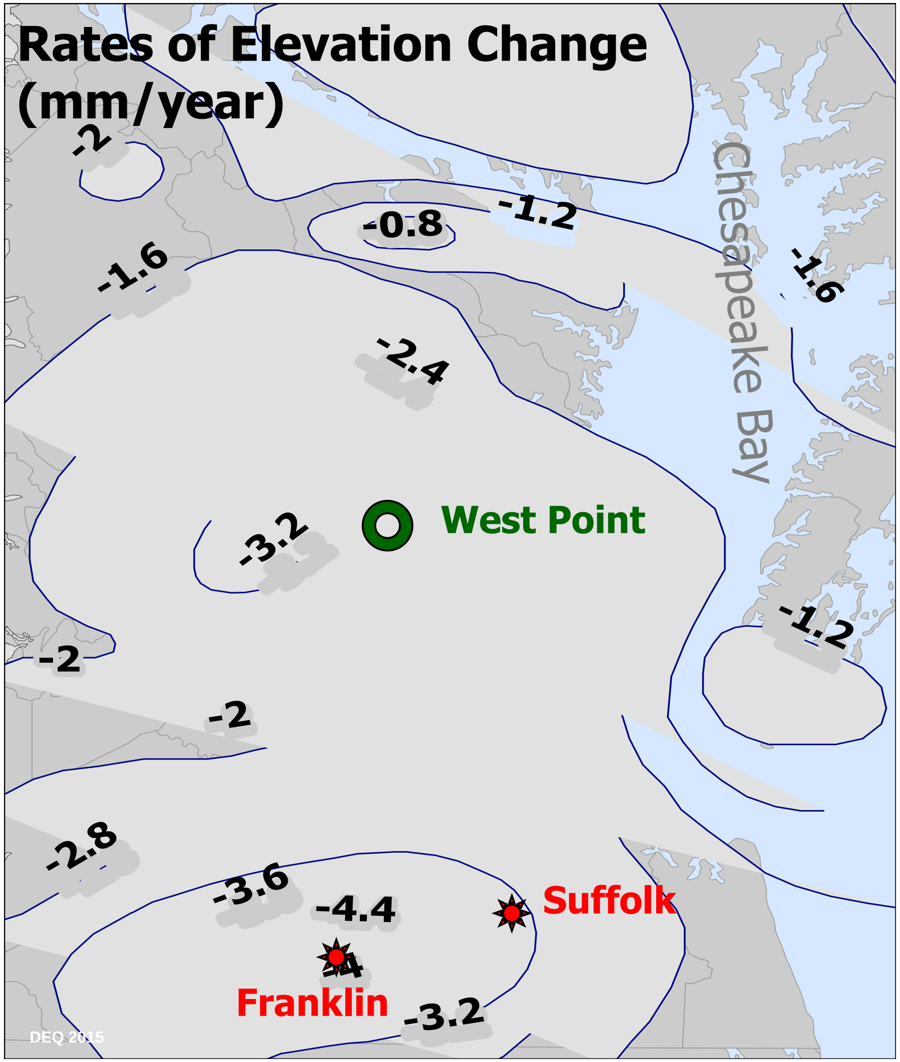
- Ever changing regulations
  - “Whack a mole” approach
    - Nutrients
      - How much is enough? – “Limit-of-Technology” (LOT) backstop threat with TMDL
    - Chlorophyll a
      - Study results could have significant impact
    - Viruses
      - Already under discussion with EPA
    - Pharmaceuticals and Personal Care Products (PPCP)
    - ????
- POTW the only regulated contributor to a very complex water quality problem
- Lack of regulatory stability

Land subsidence – *we are sinking*

- From the USGS, Circular 1392
  - 50% of observed sea-level rise is due to land subsidence
  - Aquifer-system compaction may account for more than half of the land subsidence
- Two potential solutions
  - Reduced withdrawal
  - Aquifer recharge

HAMPTON ROADS IS THE #2 LARGEST POPULATION CENTER AT RISK



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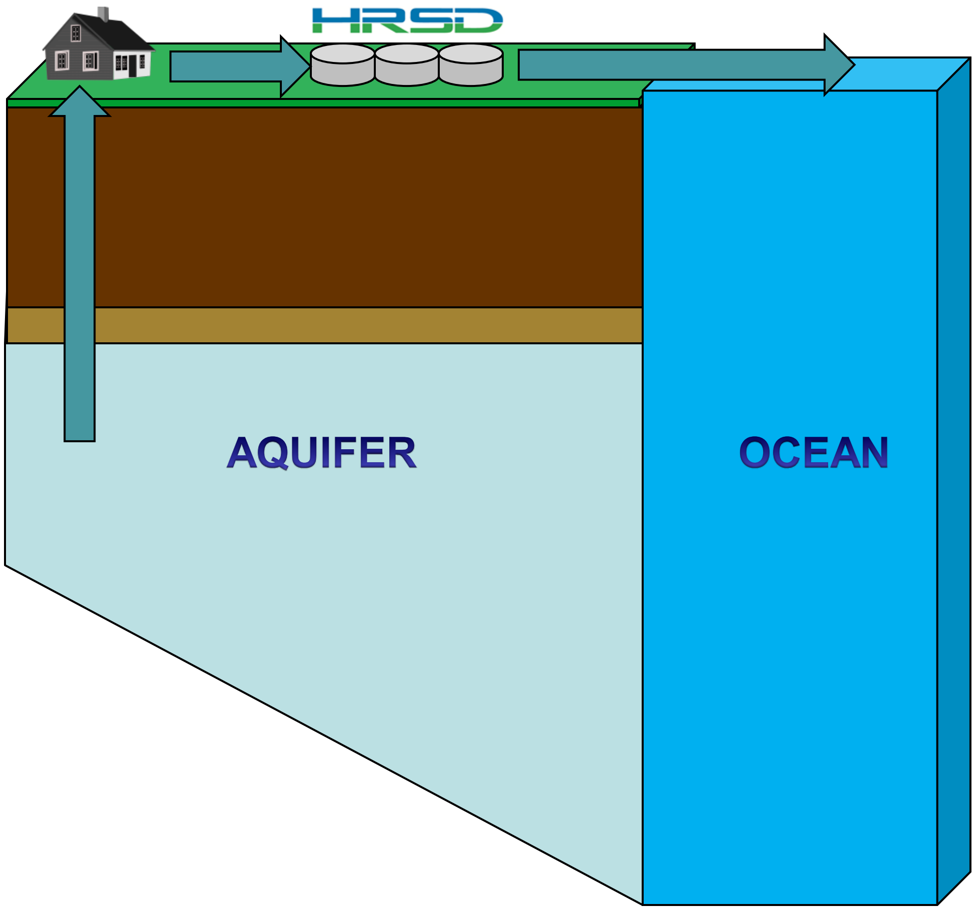
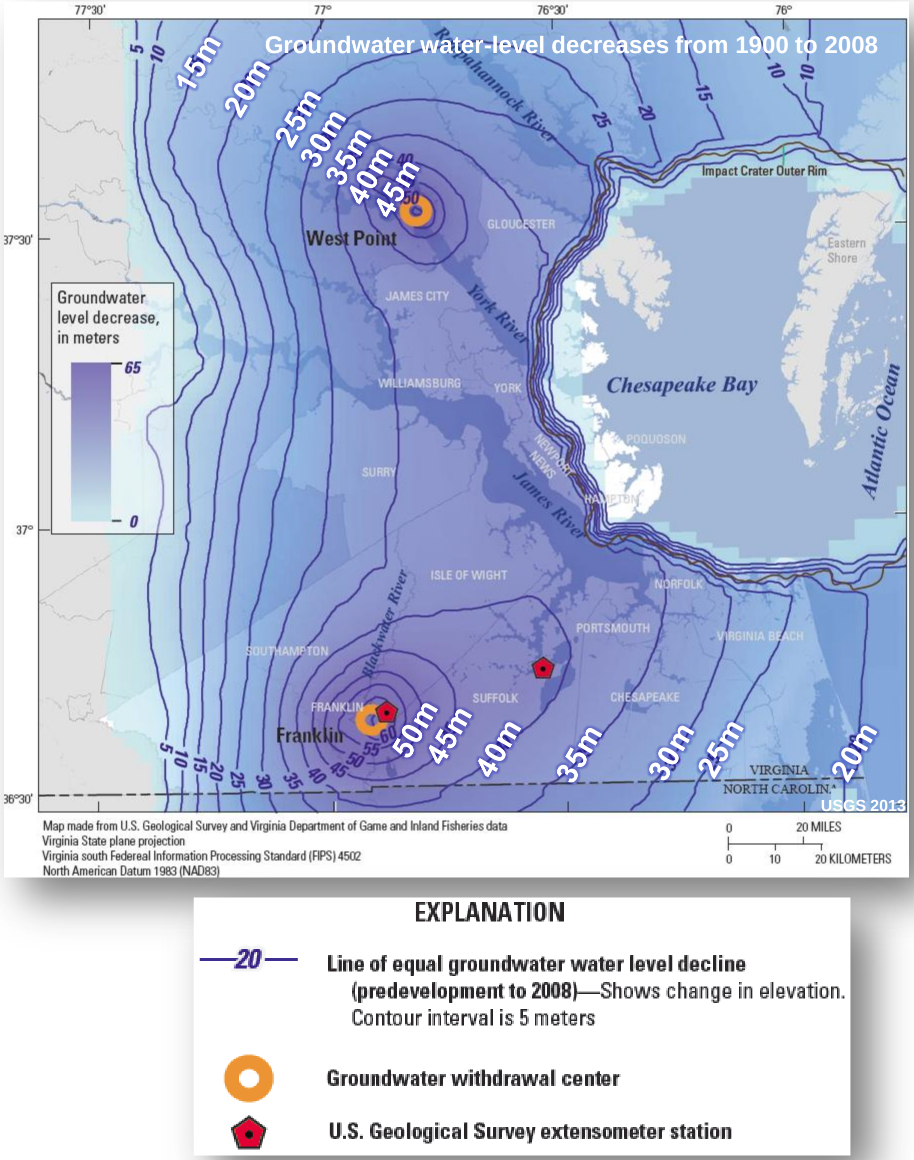
Currently mining the aquifer

- Natural aquifer recharge is not keeping up with withdrawals
- Water is cleaned and discharged to local waterways, ultimately to the ocean with no downstream use – “one and done”



Groundwater depletion

- 177 permits = 147.3 MGD
  - Currently withdrawing approximately 115 mgd
- 200,000 unpermitted "domestic" wells
  - Estimated to be withdrawing approx. 40 mgd
- Economic development implications and stranded capital



Saltwater contamination of groundwater

- Upconing of brackish water
- Lateral Intrusion of seawater
- Potentially irreversible

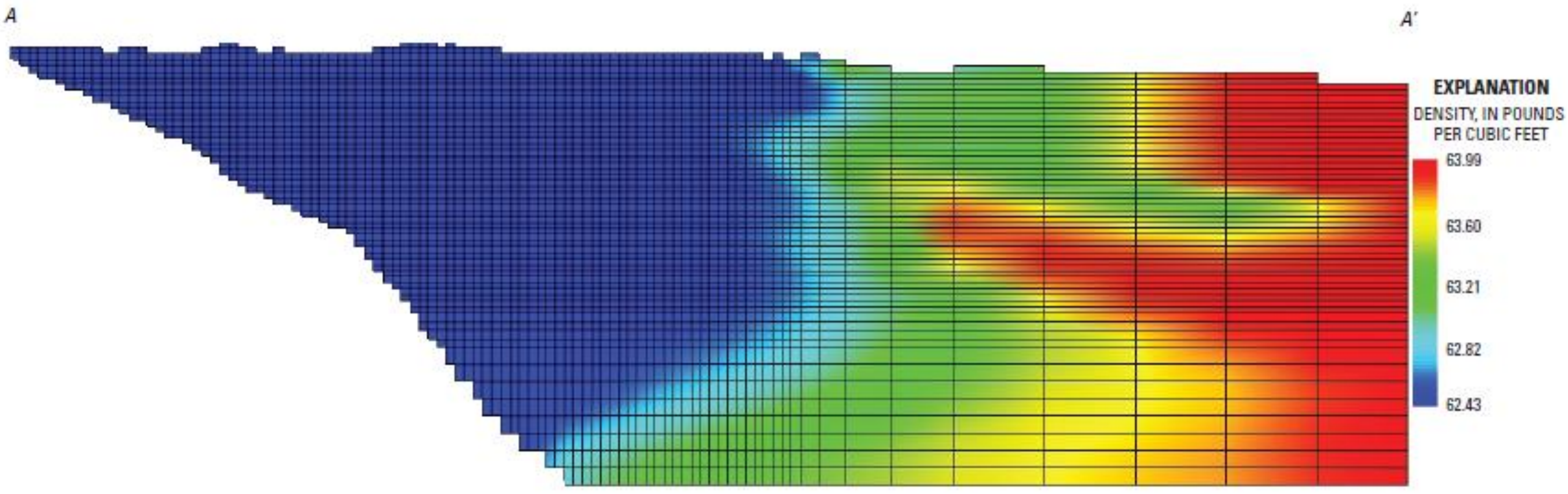
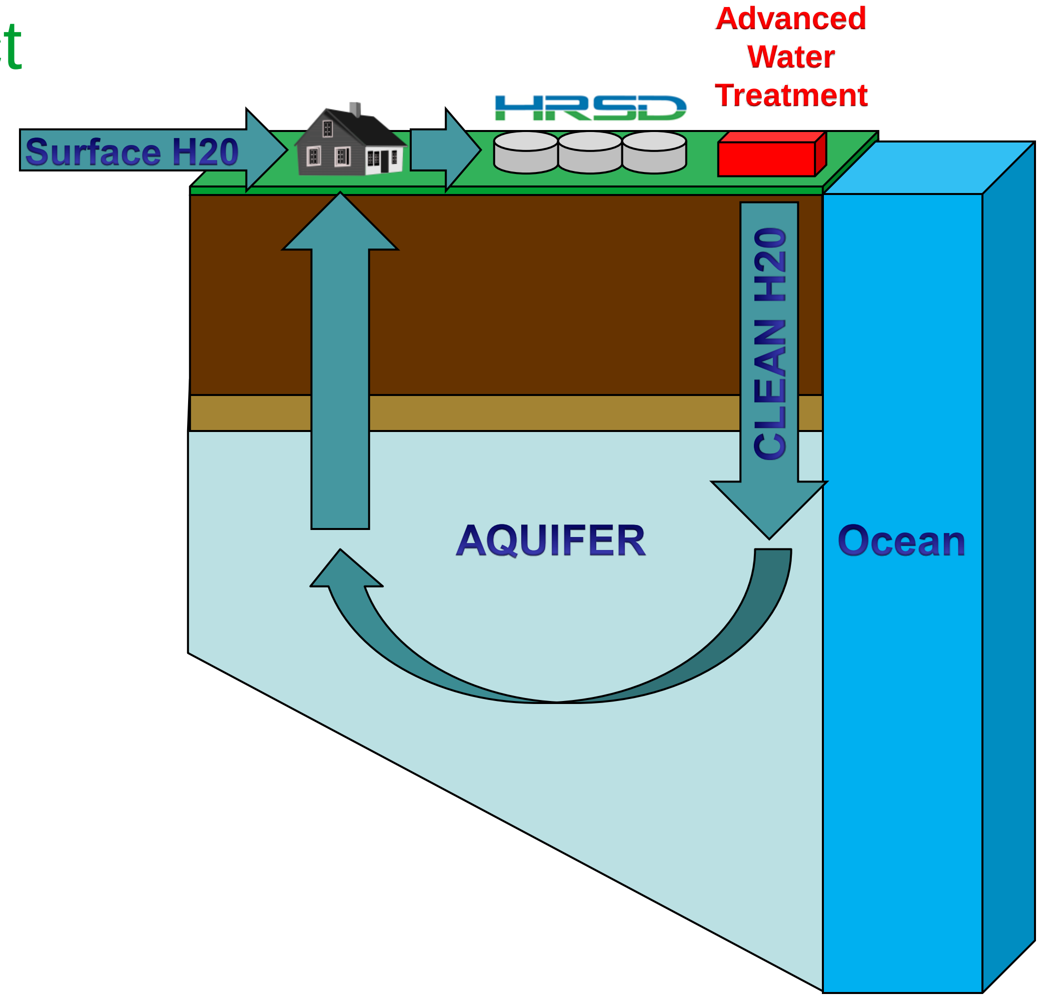


Figure A3. Simulated water density near the saltwater transition zone of the Virginia Coastal Plain. (Location of cross section shown in figure A2.)

- Can HRSD address any or all of these critical issues with a sustainable approach to water recycling?

Sustainable water recycling

- HRSD's concept - Inject clean water into the aquifer to:
  - Provide a sustainable supply of groundwater throughout Eastern Virginia
  - Reduce the rate of land subsidence
  - Protect the groundwater from saltwater contamination
  - Reduce nutrient discharges to the Bay

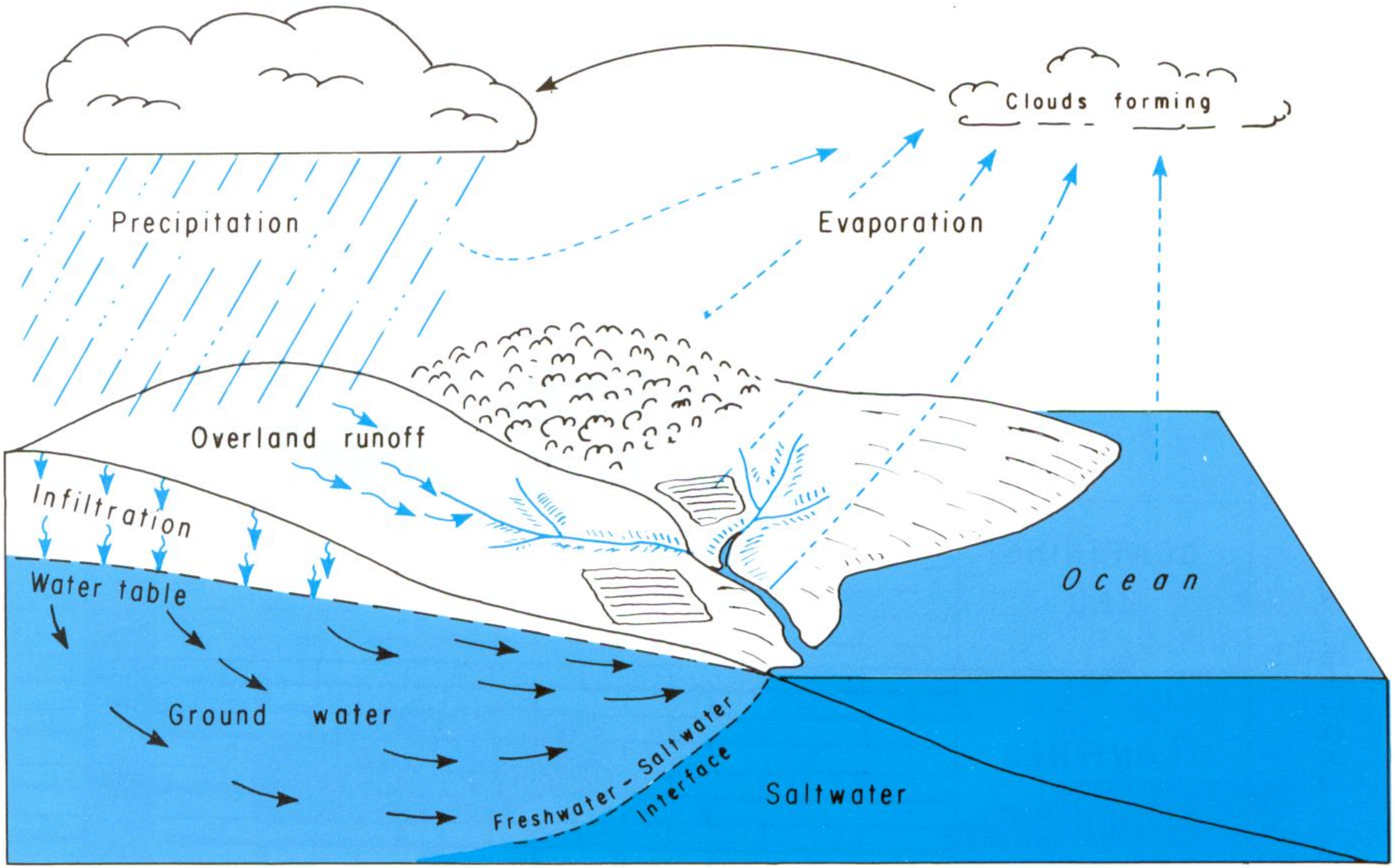


Phase 1 - Scope of Work

- Use DEQ’s groundwater model for injection feasibility
  - Procured Aquaveo, through DEQ, to perform the modeling
- Analyze wastewater characteristics to determine the appropriate advanced water treatment schemes
- Evaluate soil compatibility
- Develop conceptual capital and lifecycle costs for a model facility

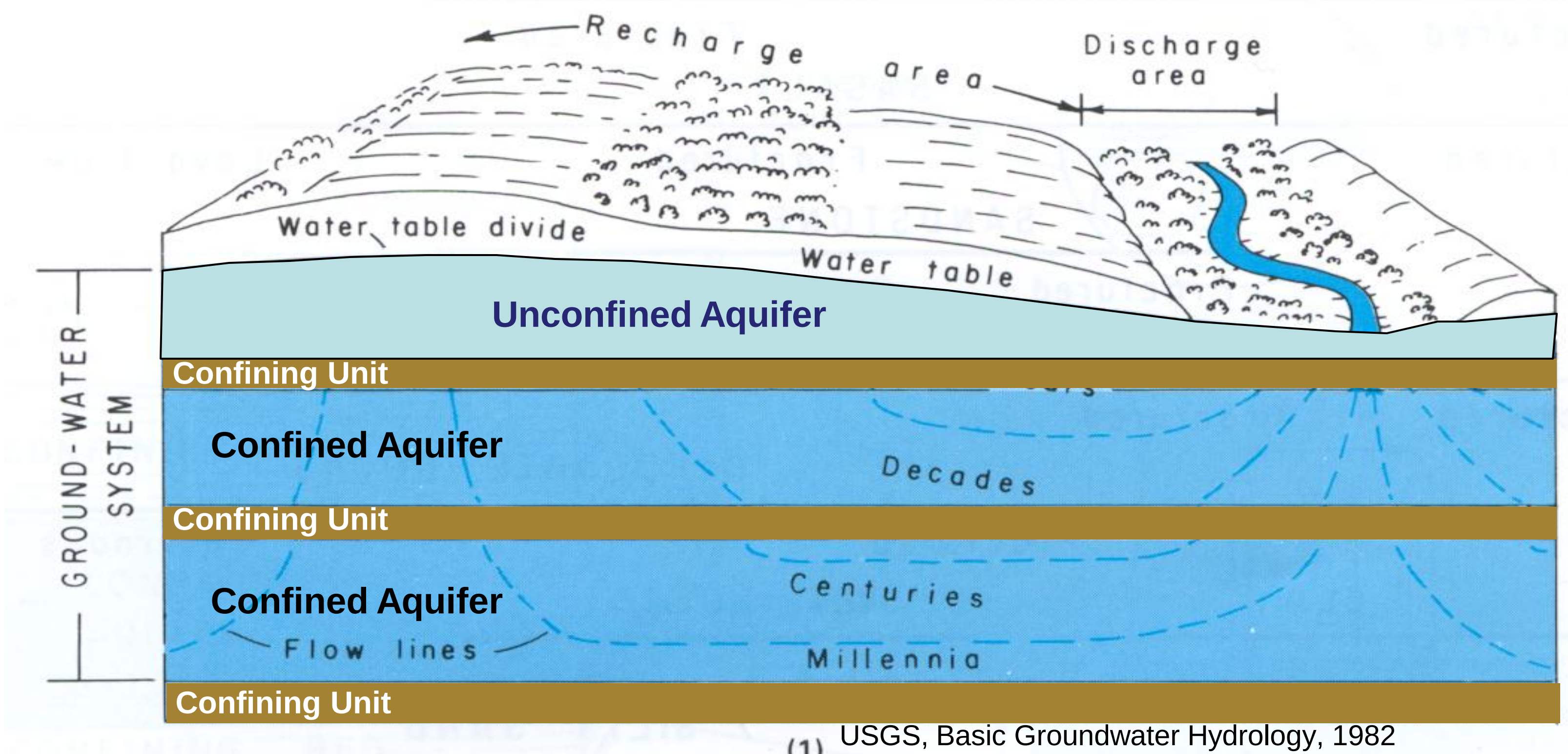
Groundwater Recap

HYDROLOGIC CYCLE



Hydrogeologic framework

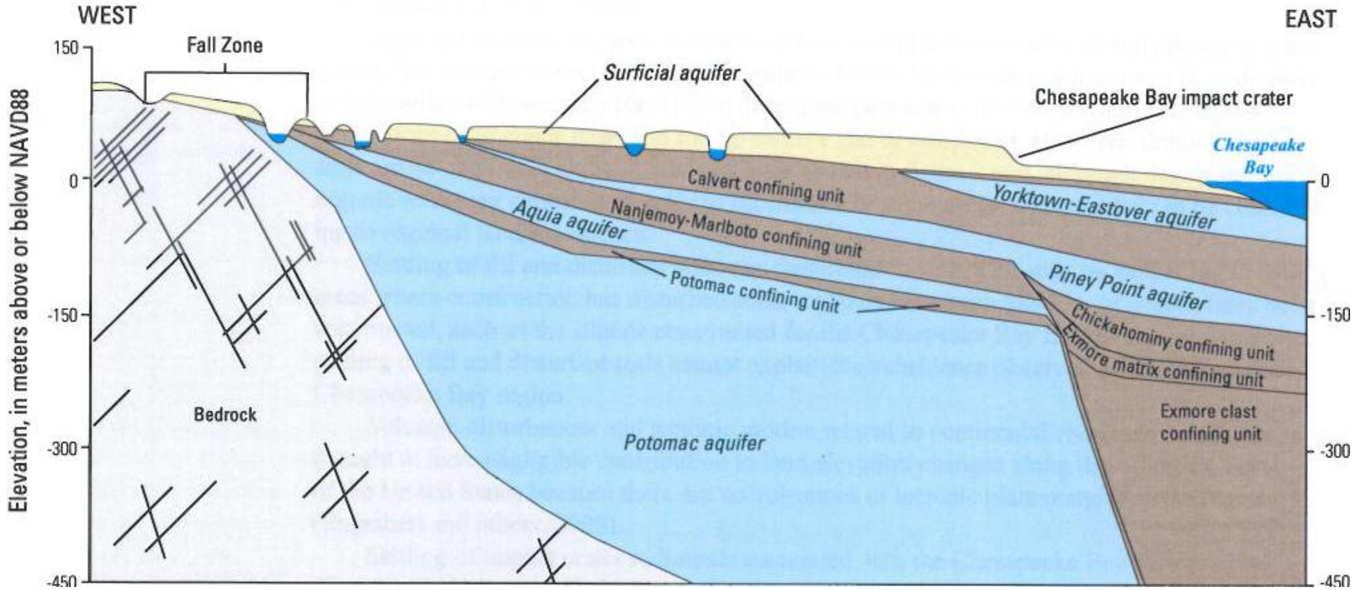
- Subsurface Geology - sediments (sands, silts, clays, shells, bedrock way down there)
- Aquifers - geologic units that easily store and transmit water
  - Unconfined
  - Confined (older water, differing water qualities)
- Confining units - geologic units that retard the flow of water



USGS, Basic Groundwater Hydrology, 1982

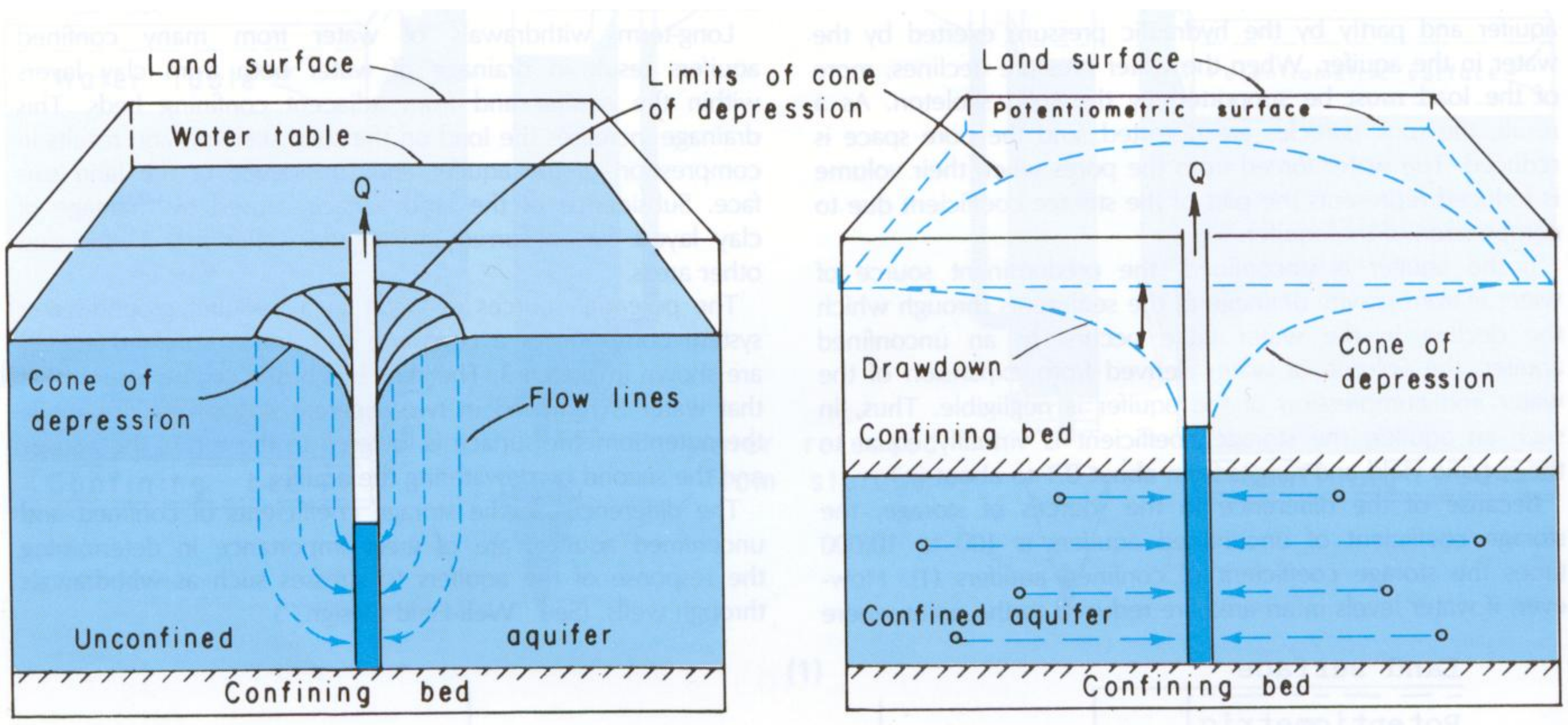
Virginia Coastal Plain Aquifer System

- VA Coastal Plain Aquifer System
  - Fall Line (around I-95 corridor) to the Ocean
  - Wedge shaped that widens and dips toward the east
  - “Layer Cake” geology of unconsolidated sands, silts, clays, shell material overlies granitic basement rock

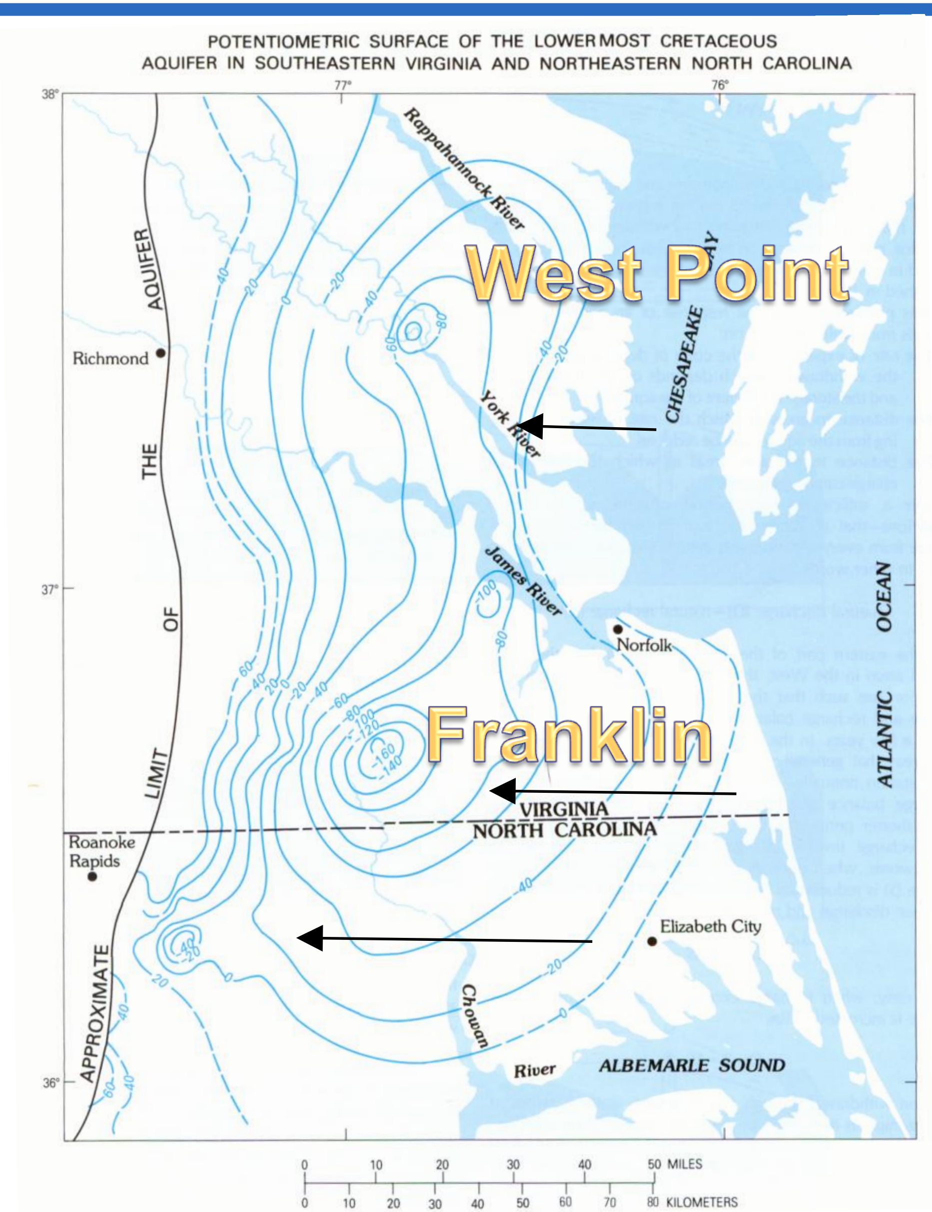


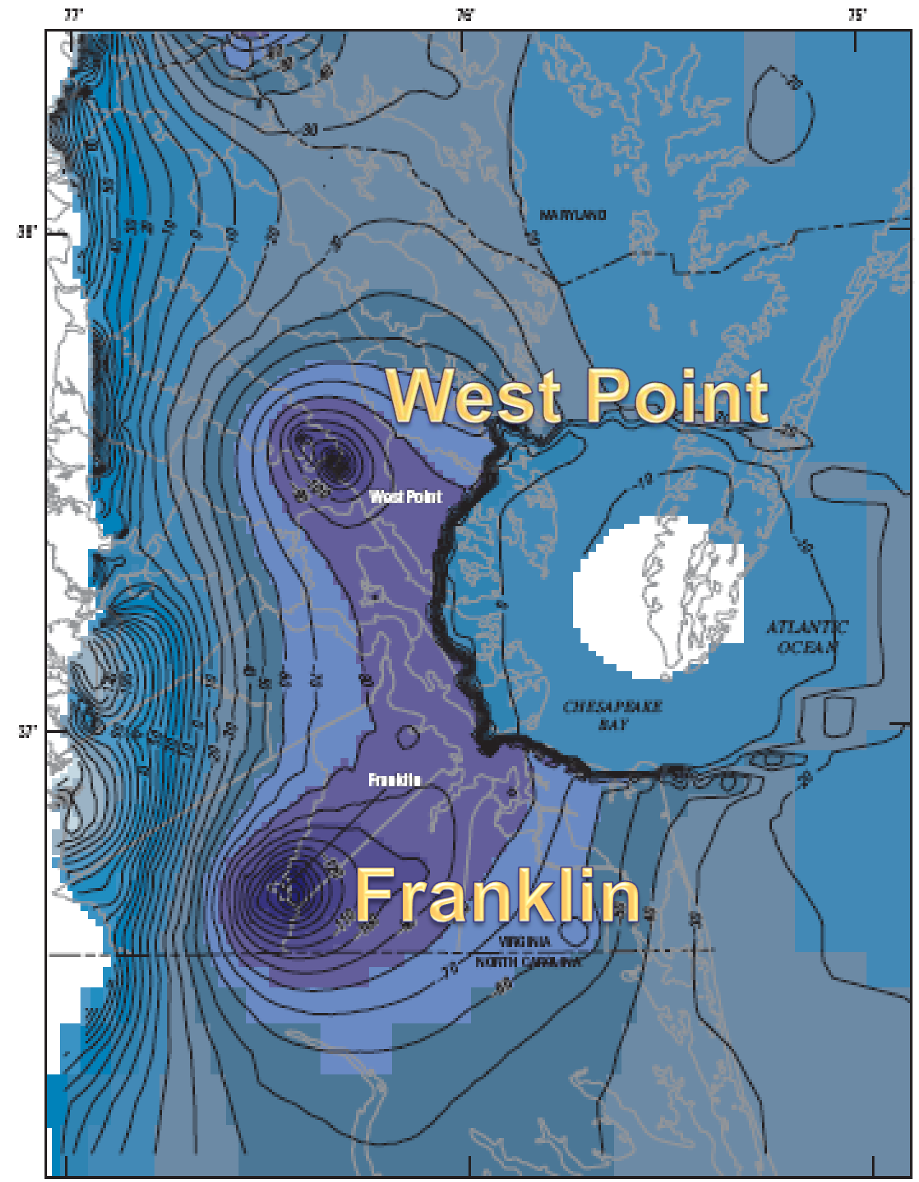
Groundwater hydraulics of the Coastal Plain of Virginia

- Groundwater flow to wells
- Drawdown
- Cone of depression

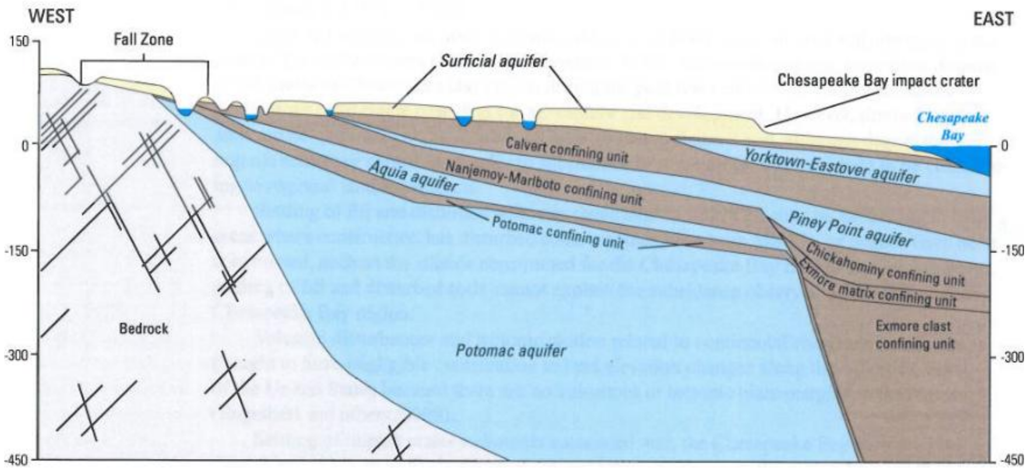


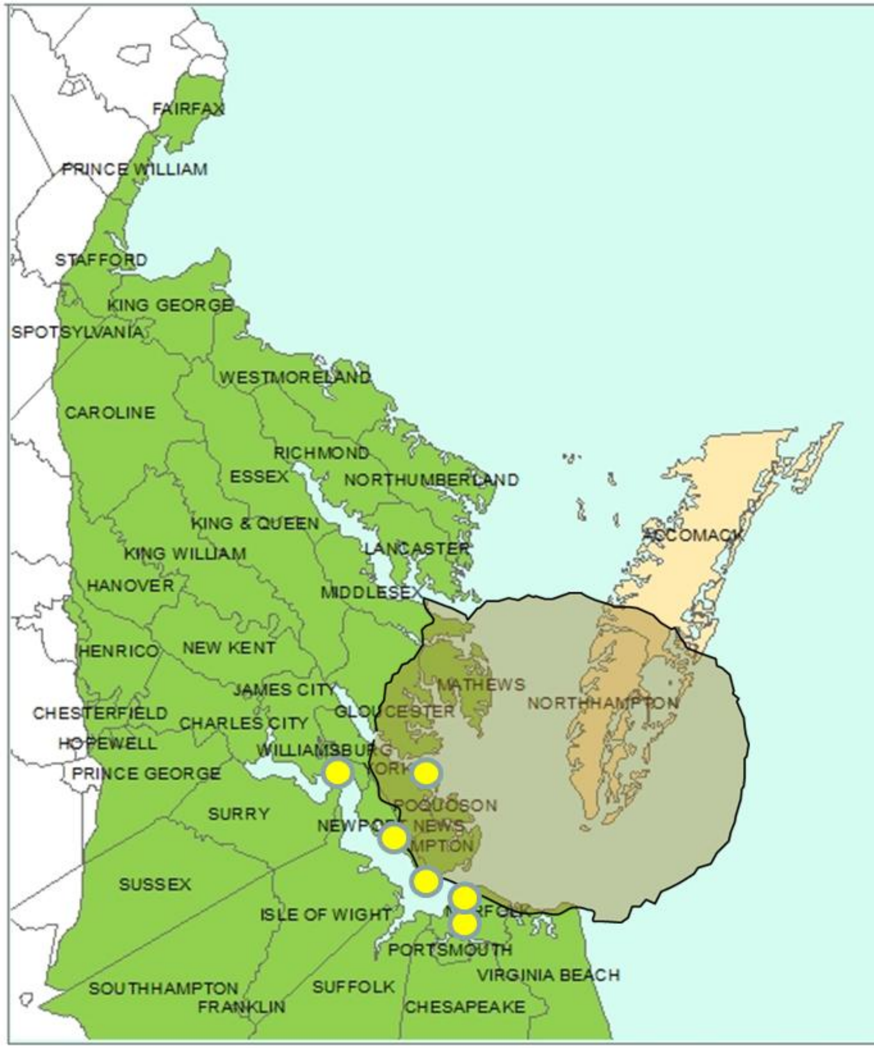
Cones of depression





- VA Coastal Plain aquifer system
- Eastern Virginia Groundwater Management Area
- Vast majority of the withdrawal from Potomac Aquifer
- Truncated by Chesapeake Bay Impact Crater

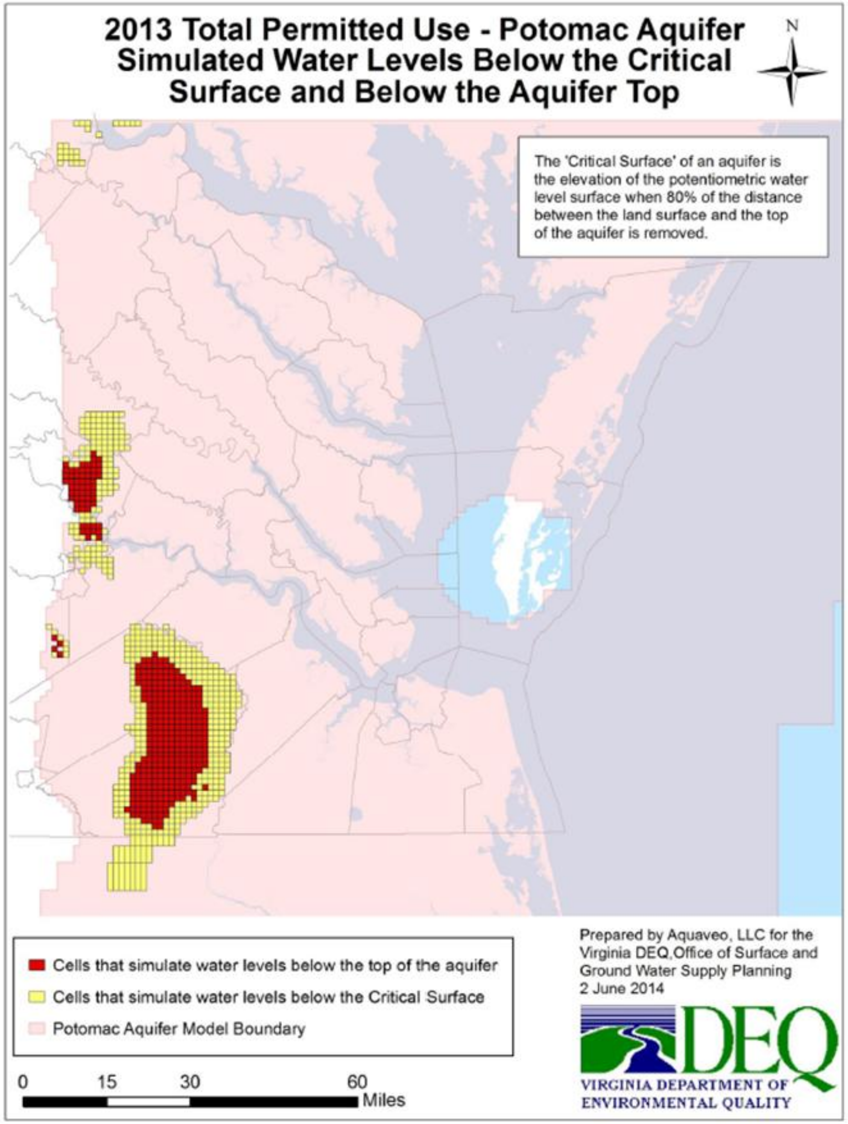




Effective: January 1, 2014
Prepared By: Virginia Department of Environmental Quality
Groundwater Withdrawal Permitting Program

Hydraulic issues

- Over-allocated withdrawal
  - Water levels falling several feet/yr
  - Some water levels below the aquifer tops in western Coastal Plain
- Model simulations predict the total permitted withdrawals are unsustainable
  - Areas below regulatory criteria
  - Areas experience aquifer dewatering

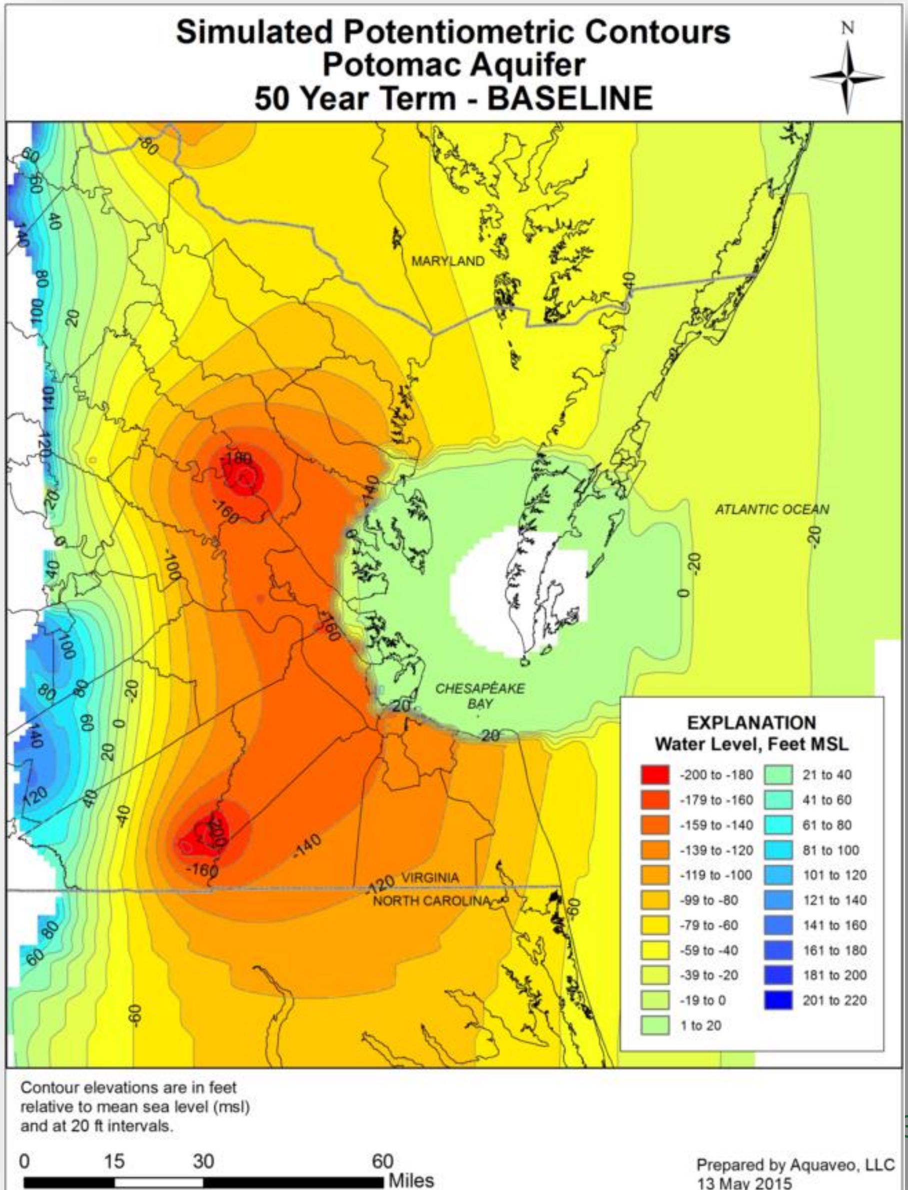


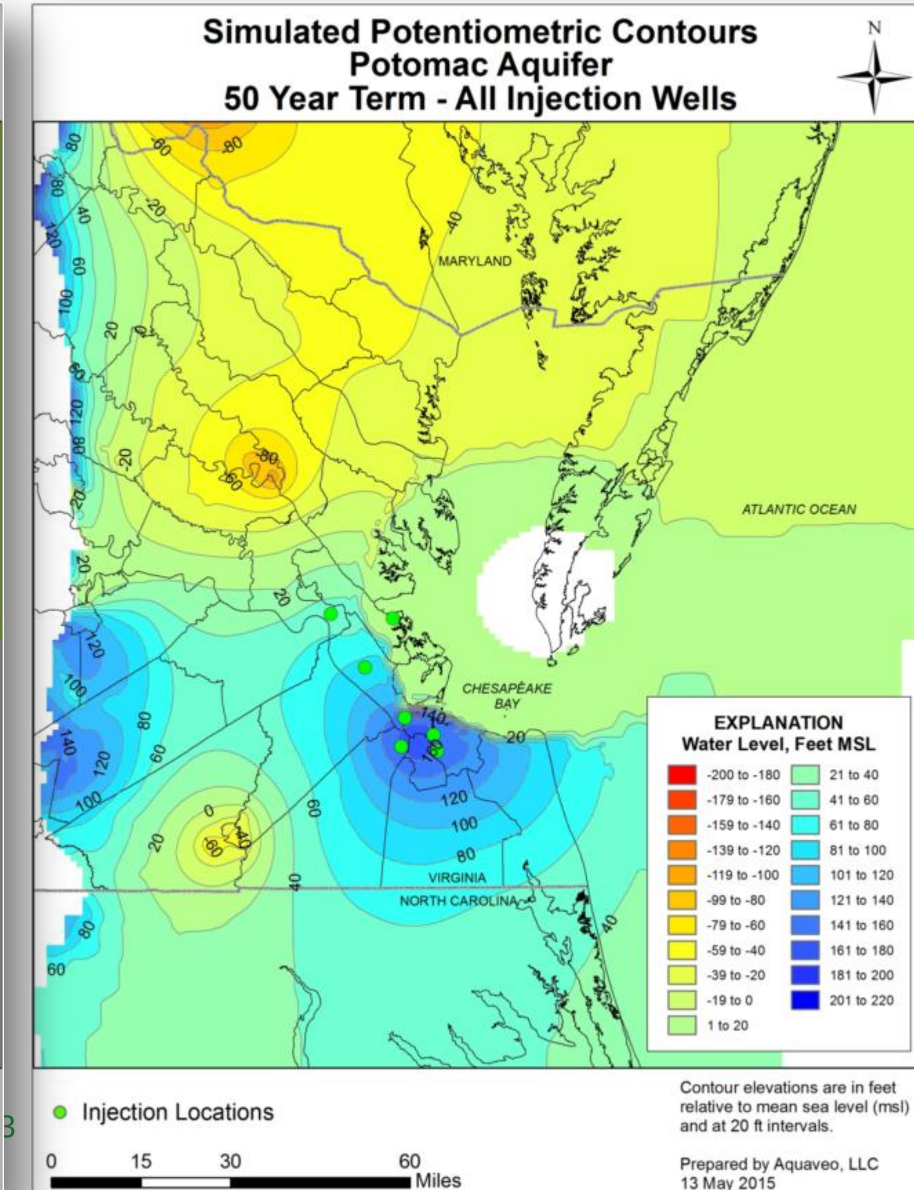
Groundwater Modeling and Geochemistry

Groundwater modeling

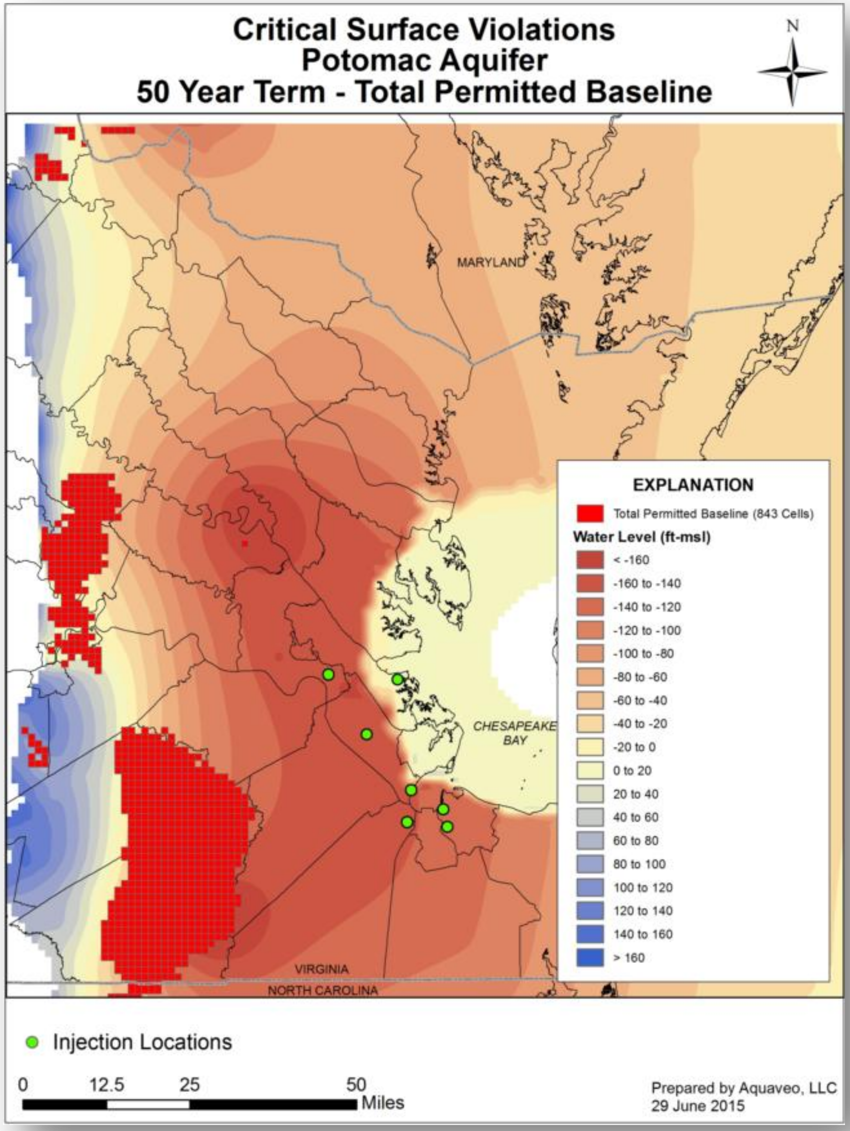
- Modeling quantifies the impact of groundwater injection
  - Is there a measurable benefit to the aquifer system (DEQ criteria)?
  - What pressures are required and what does well field look like?

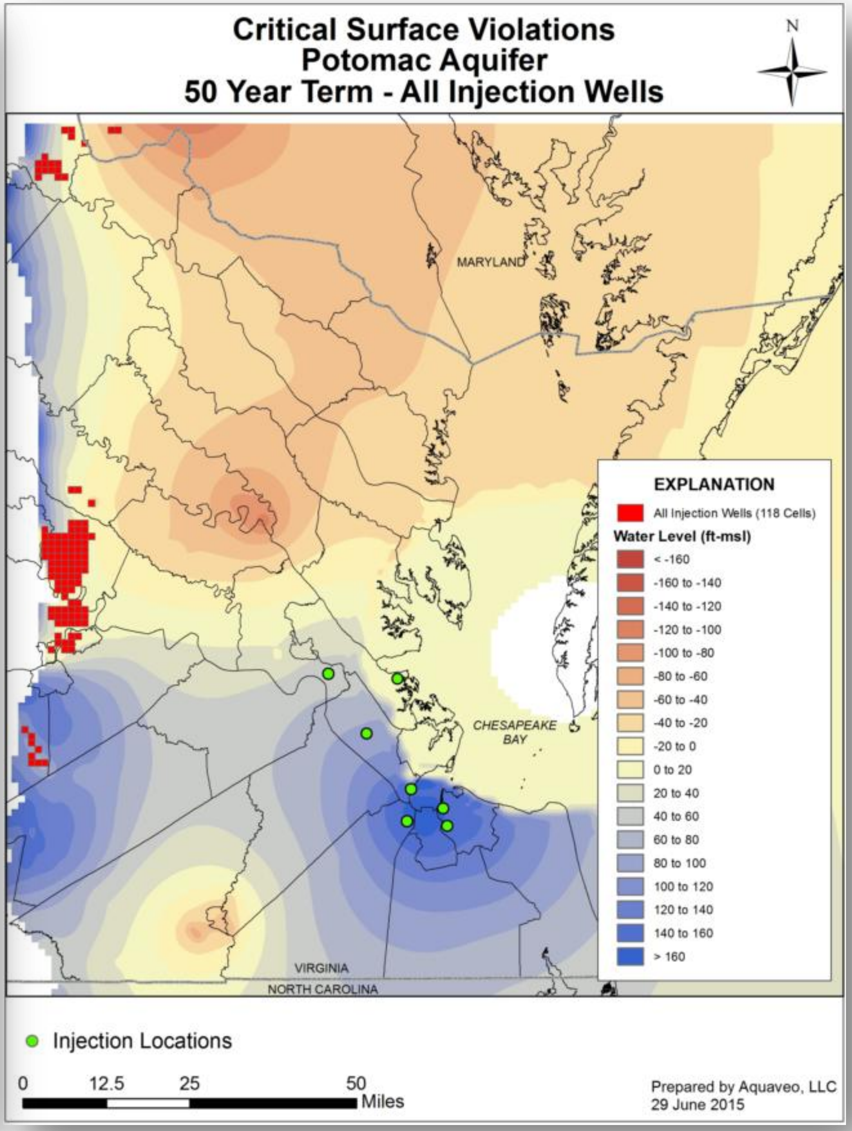
Potomac Aquifer water levels before and after injection





The aquifer recovers! - Critical cells: Potomac Aquifer





Groundwater modeling results summary

- Injecting clean water eliminates Critical Cells
- Injection benefits the entire Eastern Virginia Groundwater Management Area
- Dispersed location of plants is beneficial for injection – required pressures are reasonable
- Confirmed "wireless" water distribution concept – entire aquifer benefits
- York River injection well site will need to be off plant site - outside of the crater limits

- Injectate must be compatible with the native groundwater and the aquifer material
  - Operational issues
  - Regulatory issues
- Physical plugging
  - Disrupting clay particles
  - Precipitating minerals
  - Can clog the screen, filterpack and aquifer immediately around the well
- Dissolution/mobilization of metals

Purified wastewater triggers release of arsenic within aquifer, study finds

The Orange County Water District has operated a potable reuse and groundwater replenishment system since 2008. Treated wastewater is purified using a mix of microfiltration, reverse osmosis, ultraviolet light and hydrogen peroxide. It is then added to a vast underground aquifer. (Carlos Chavez / Los Angeles Times)

By MONTE MORIN
contact the reporter

SEPTEMBER 4, 2015, 3:20 PM

When it comes to the science of transforming sewage into tap water - or potable reuse - engineers say there's no question the product is clean enough to drink.

The trouble is, researchers are now learning that this drinking water may be too clean to store underground without special treatment.

- Determine injection water chemistry based on potential water treatment processes:
  - RO/UVAOP
  - NF/UVAOP
  - BAC/GAC
- Compare the clean water from those 3 processes to the to native groundwater (data from NWIS)
  - each individual Potomac aquifer zone (Upper, Middle and Lower)
  - mixing between treated water and native groundwater
- Evaluate reactions between treated water and aquifer mineralogy (using Chesapeake core data)
  - 99% inert material (quartz, feldspars, etc).
  - Remaining material can be problematic (clays)

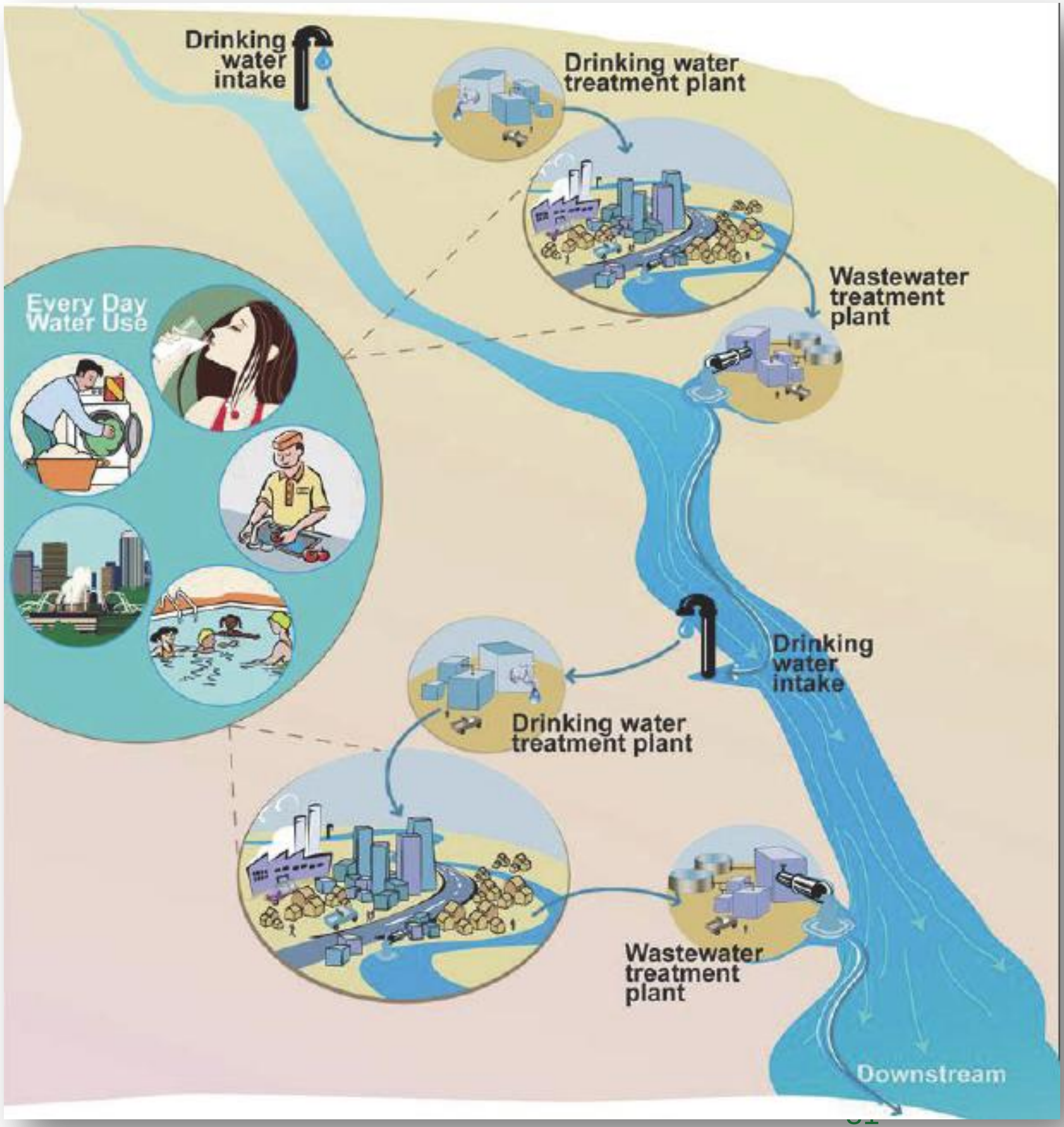
Geochemical compatibility

- Treatment processes produce water with varying aquifer and groundwater compatibility
- **GAC/BAC and Nanofiltration (NF)** – generally more compatible
- **RO** – requires adding salt and alkalinity to be compatible

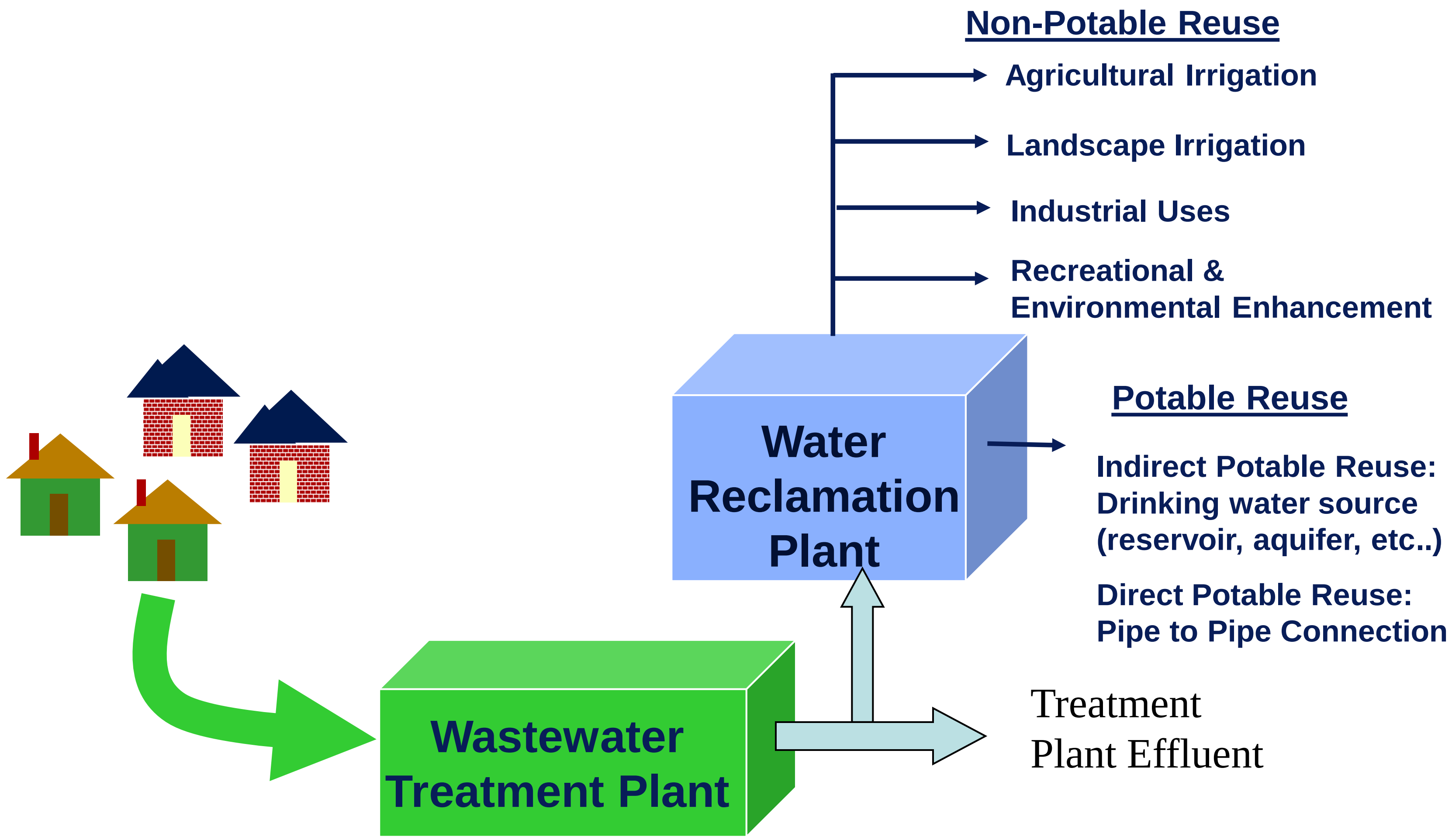
Advanced Water Treatment for Recycling Water

De Facto water recycling

- **Common throughout the world and in Virginia**
  - **James River**
  - **Shenandoah**
  - **Potomac**
  - **Roanoke River Basin (Lake Gaston)**



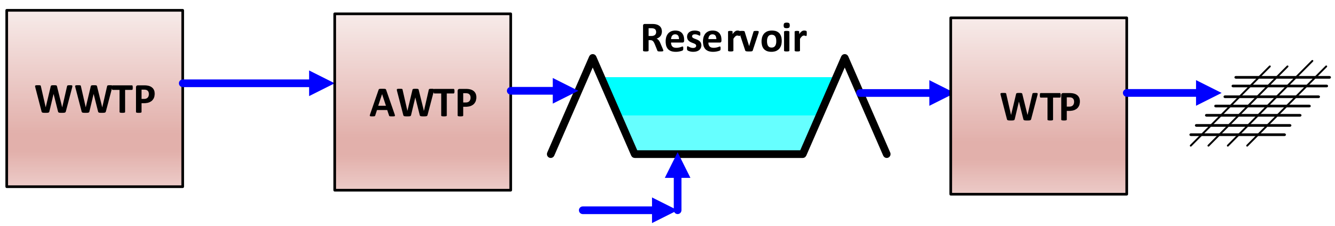
Water recycling opportunities



Operational water recycling projects

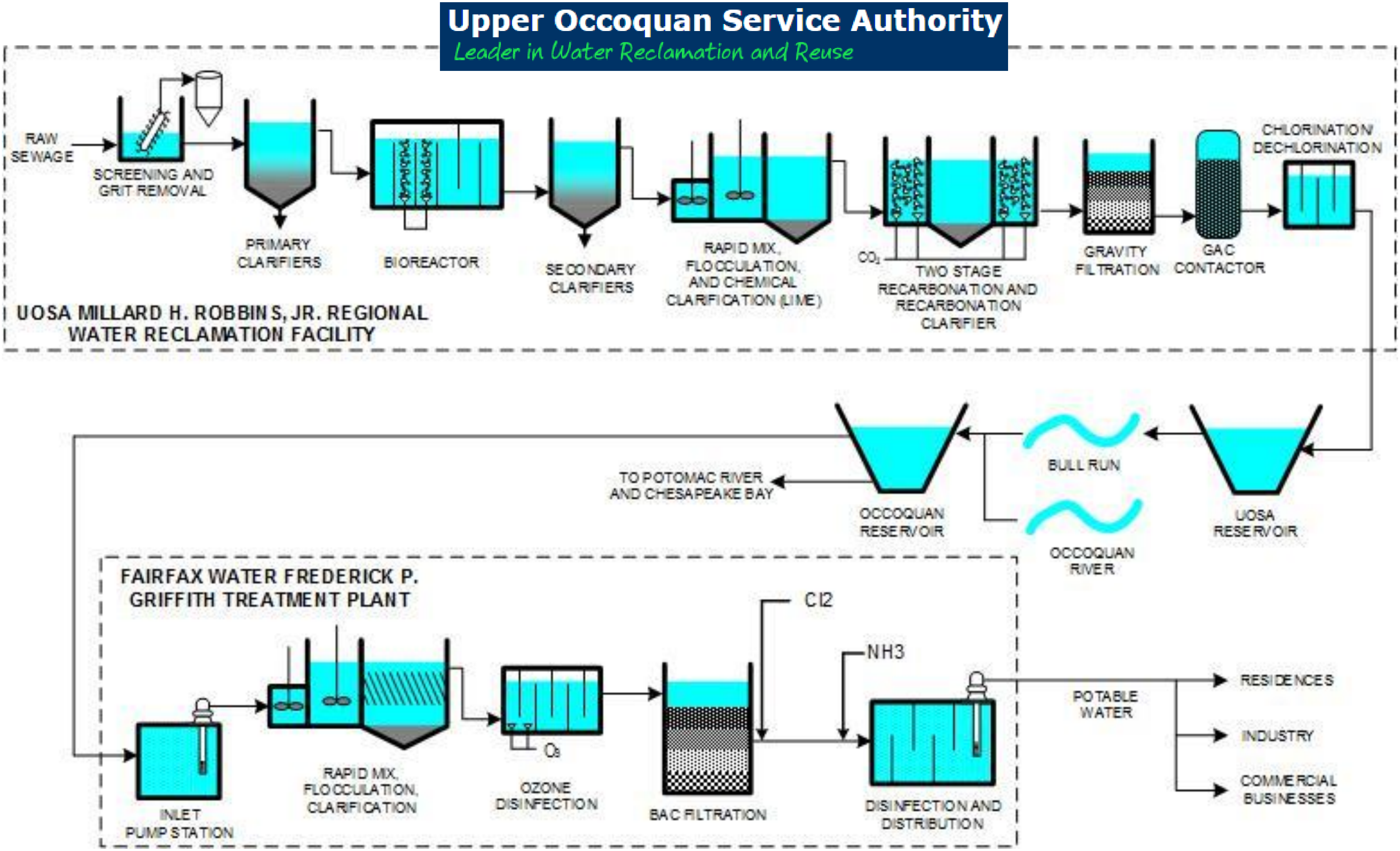
Project	Location	Type of Potable Reuse	Year	Capacity	Current Advanced Treatment Process
Montebello Forebay, CA	Coastal	GW recharge via spreading basins	1962	44 mgd	GMF + Cl_2 + SAT (spreading basins)
Windhoek, Namibia	Inland	Direct potable reuse	1968	5.5 mgd	O_3 + Coag + DAF + GMF + O_3/H_2O_2 + BAC + GAC + UF + Cl_2 (process as of 2002)
UOSA, VA	**Inland**	**Surface water augmentation**	**1978**	**54 mgd**	**Lime + GMF + GAC + Cl_2**
Hueco Bolson, El Paso, TX	Inland	GW recharge via direct injection and spreading basins	1985	10 mgd	Lime + GMF + Ozone + GAC + Cl_2
Clayton County, GA	Inland	Surface water augmentation	1985	18 mgd	Cl_2 + UV disinfection + SAT (wetlands)
West Basin, El Segundo, CA	Coastal	GW recharge via direct injection	1993	12.5 mgd	MF + RO + UVAOP
Scottsdale, AZ	Inland	GW recharge via direct injection	1999	20 mgd	MF + RO + Cl_2
Gwinnett County, GA	Inland	Surface water augmentation	2000	60 mgd	Coag/floc/sed + UF + Ozone + GAC + Ozone
NEWater, Singapore	Coastal	Surface water augmentation	2000	146 mgd (5 plants)	MF + RO + UV disinfection
Los Alamitos, CA	Coastal	GW recharge via direct injection	2006	3.0 mgd	MF + RO + UV disinfection
Chino GW Recharge, CA	Inland	GW recharge via spreading basins	2007	18 mgd	GMF + Cl_2 + SAT (spreading basins)
GWRS, Orange County, CA	Coastal	GW recharge via direct injection and spreading basins	2008	70 mgd	MF + RO + UVAOP + SAT (spreading basins for a portion of the flow)
Queensland, Australia	Coastal	Surface water augmentation	2009	66 mgd via three plants	MF + RO + UVAOP
Arapahoe County, CO	Inland	GW recharge via spreading	2009	9 mgd	SAT (via RBF) + RO + UVAOP
Loudoun County, VA	**Inland**	**Surface water augmentation**	**2009**	**11 mgd**	**MBR + GAC + UV**
Big Spring (Wichita Falls), TX	Inland	Direct potable reuse through raw water blending	2013	1.8 mgd	MF + RO + UVAOP

Water recycling - Surface water augmentation



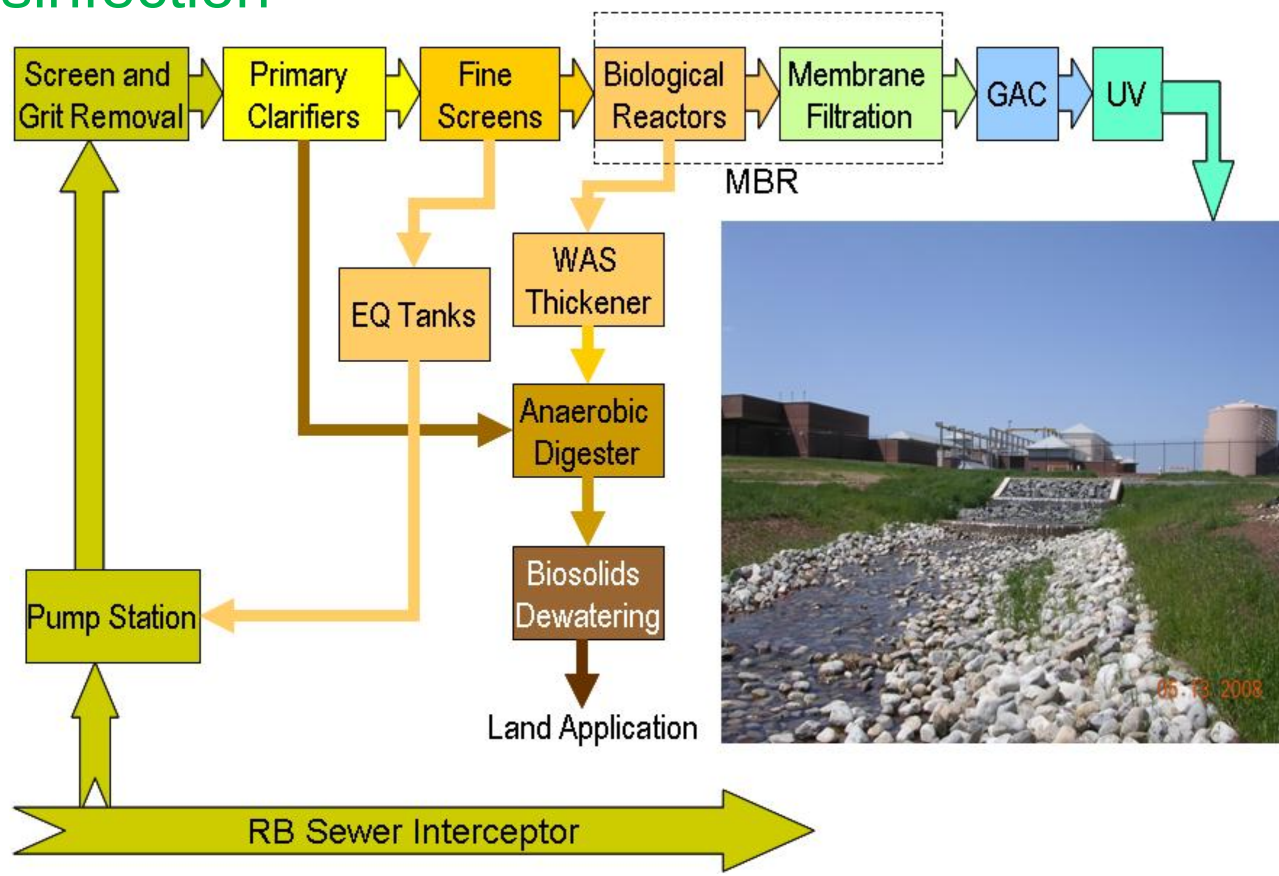
- Examples:
  - **Upper Occoquan Service Authority**
    Leader in Water Reclamation and Reuse
    - (Northern Virginia)
  - Gwinnett County (Georgia)
  - Singapore NEWater

Water recycling in Virginia since 1978 (54 MGD)



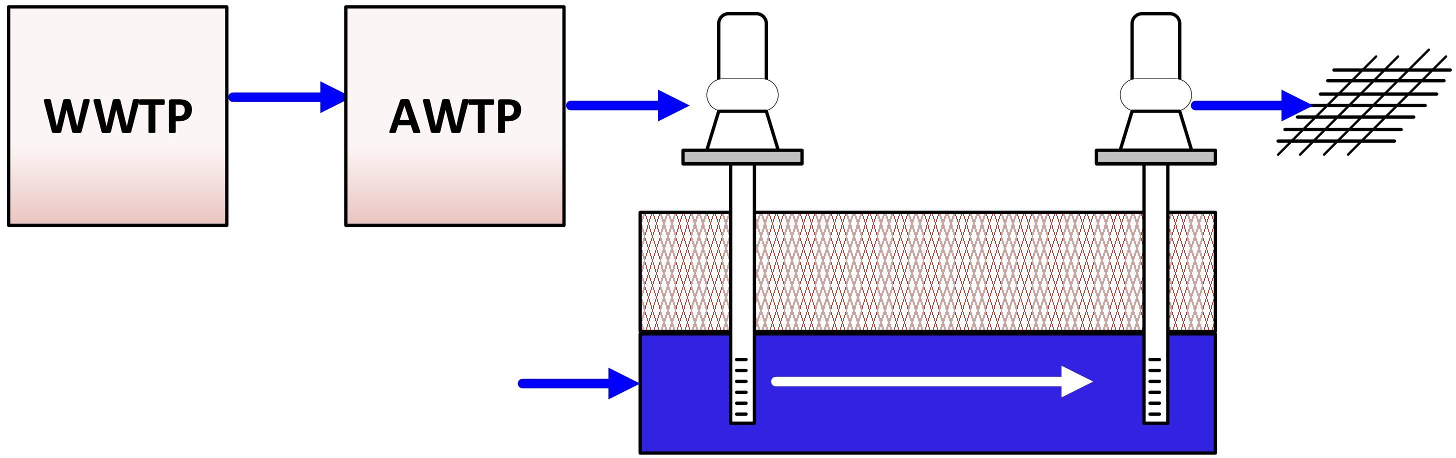
Loudoun Water Broad Run WWTP (11 MGD) MBR + GAC

- Membrane Bioreactor (MBR) 5-stage BNR + alum addition
- Hollow fiber membrane is microfiltration
- GAC for removal of refractory COD and organic N
- UV disinfection



Water recycling - Groundwater recharge via direct injection

This is a form of Indirect Potable Reuse



- Examples:
  - Groundwater Replenishment System (Orange County, CA)
  - West Basin (El Segundo, CA)
  - Los Alamitos (Long Beach, CA)
  - Scottsdale Water Campus (AZ)
  - Hueco Bolson (El Paso, TX)

Recycled water quality - Functional targets

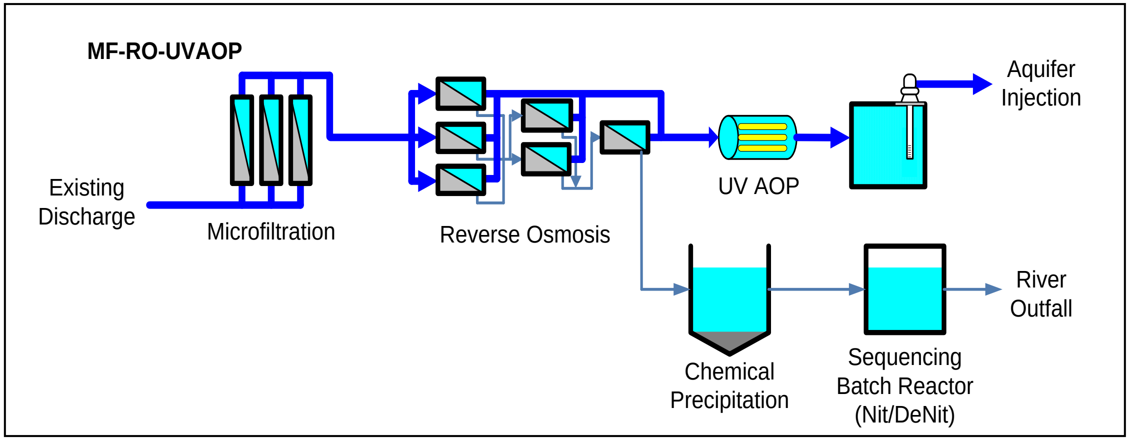
Two major water quality aspects to consider:

- Aquifer “centric” issues
  - Anti-degradation criterion – determined by others (DEQ, stakeholders, EPA)
  - Aquifer compatibility – water chemistry interactions (pH, alkalinity, etc.)

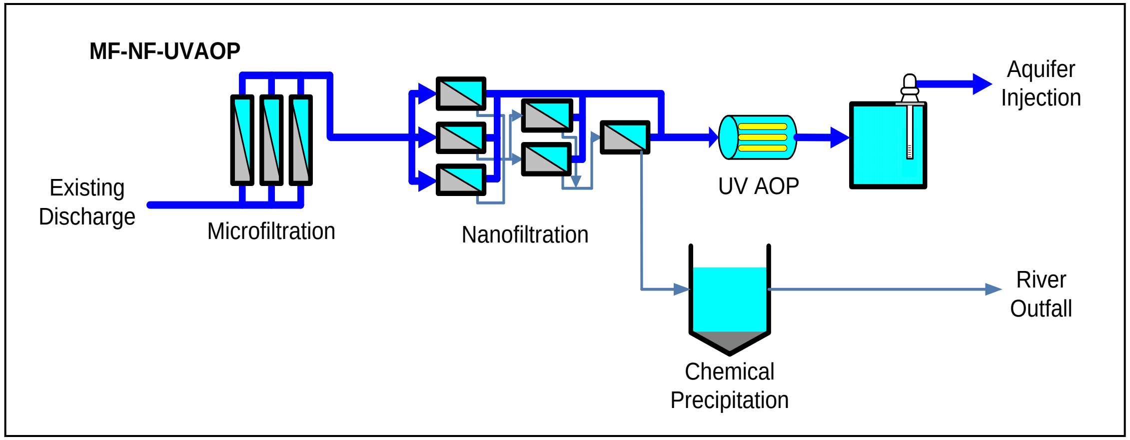
- User (human-health) “centric” issues
  - Injectate water quality based on regulatory definitions:
    - Drinking water standards (MCLs)
    - Water Reuse standards (no VA injection standard yet)
  - Occoquan Reservoir and Dulles Corridor Standards?

Advanced water treatment alternatives

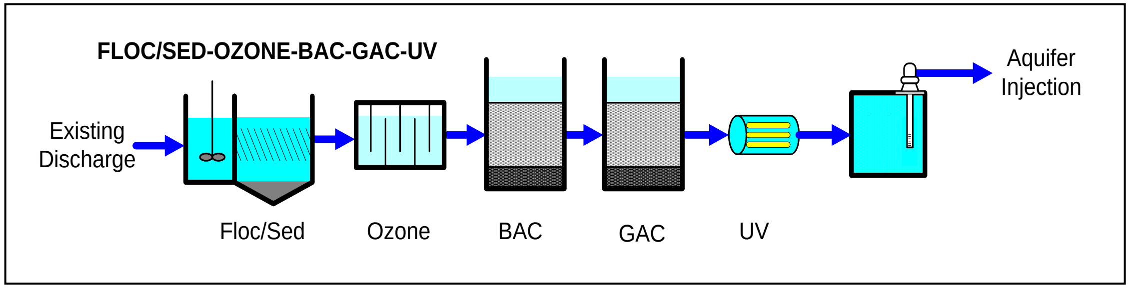
Reverse Osmosis (RO)



Nanofiltration (NF)

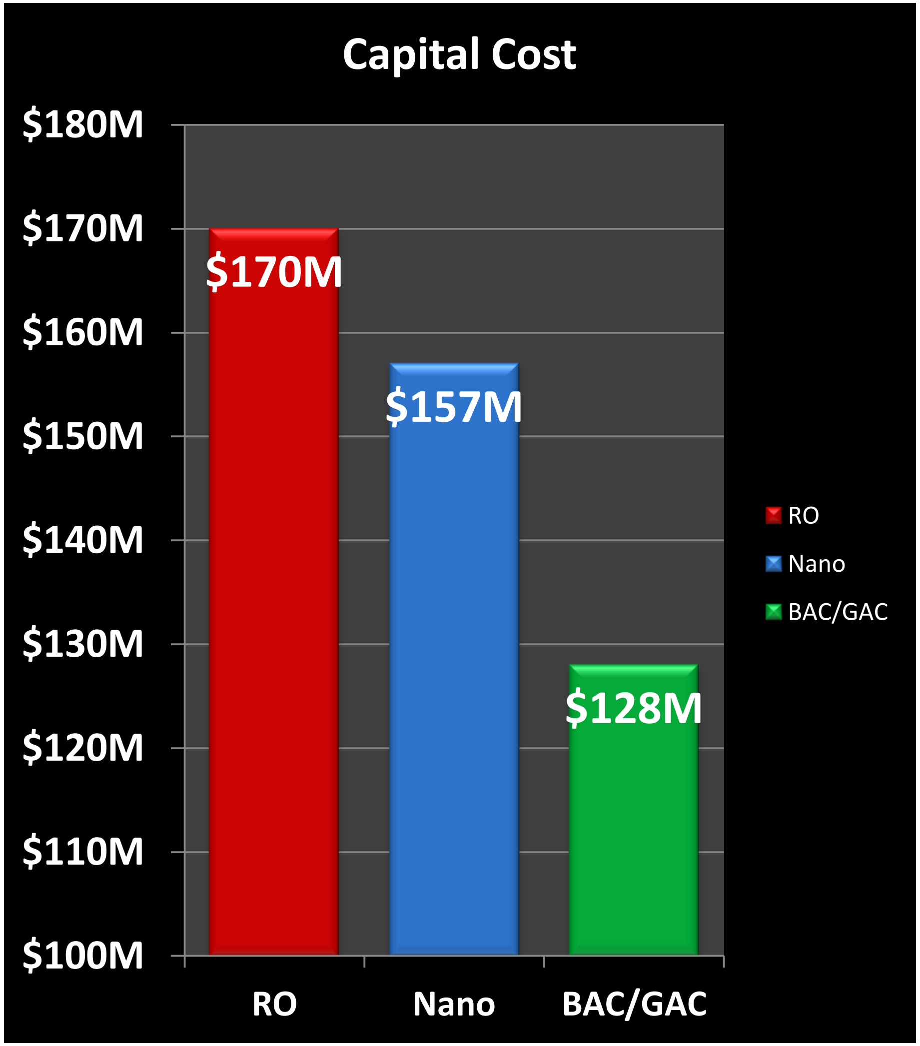


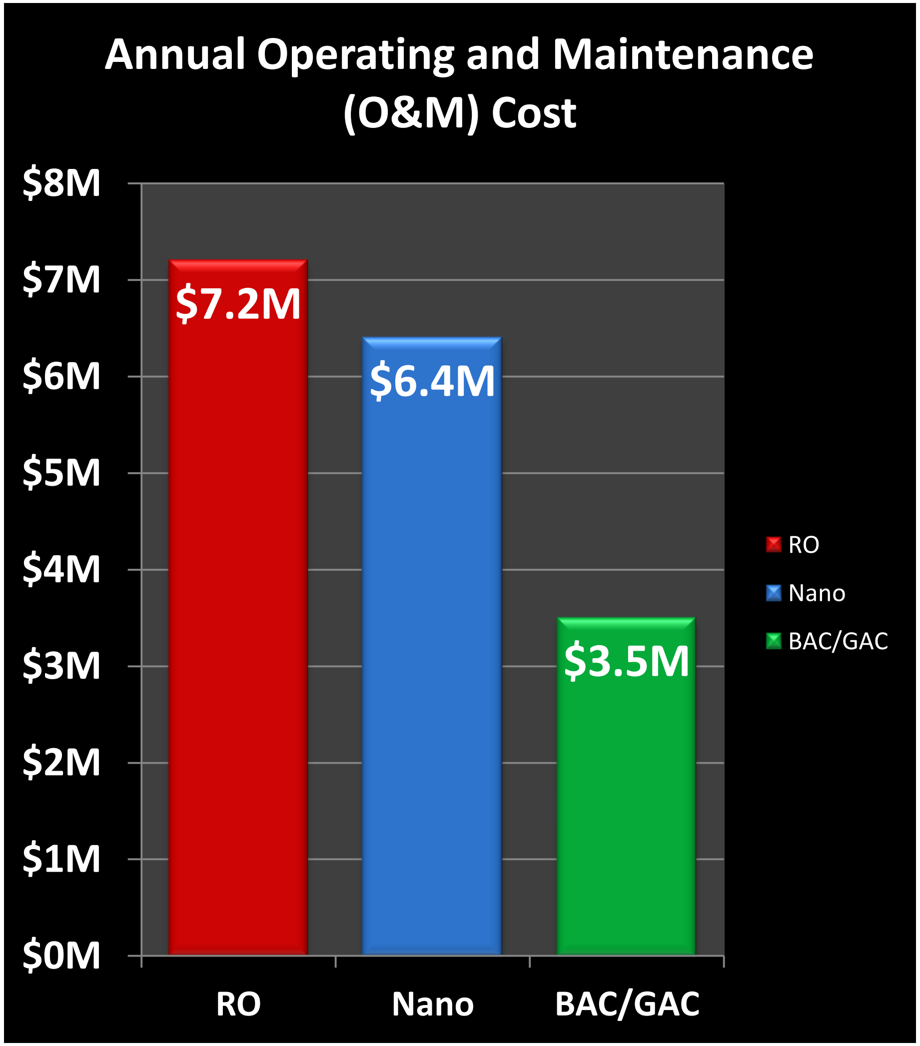
Biologically-Active Granular Activated Carbon (BAC)/ Granular Activated Carbon (GAC)



Conceptual Costs Estimates

Cost for 20 MGD





Cost Summary

- Total project in the $1 billion range (120 mgd)
  - For 6 or 7 plants (not CE or Atlantic)
  - York needs additional study to locate injection site
- Annual operating costs $21 - $43 M
- Sets stage for integrated planning discussion
- Operating costs (low end) could be recovered with very reasonable permitted withdrawal fee
  - Provides incentive for permits without significant reserves for potential future needs – right sized
  - Encourages conservation

Conclusion and Next Steps

Conclusion – Summary of Benefits

- Regulatory stability for treatment processes
- Potential reduction in the rate of land subsidence
- Sustainable source for groundwater replenishment
- Protection of groundwater from saltwater contamination
- Eliminates need to pipe recycled water to specific users – “wireless” solution
- Significantly reduced discharge into the Chesapeake Bay (only during wet weather)
  - Increases available oyster grounds
  - Creates source of nutrient allocation to support other needs

HRSD Uniquely positioned

- Large regional political subdivision
- Governor appointed Commissioners
- Broad powers granted in enabling legislation
  - ***"The exercise of the powers granted by this act shall be in all respects for the benefit of the inhabitants of the Commonwealth and for the promotion of their safety, health, welfare, convenience and prosperity,…"***
  - ***"This act, being necessary for the welfare of the Commonwealth and its inhabitants, shall be liberally construed to effect the purposes thereof."***
- No downstream low-flow issues from HRSD plants
- Daily capacity to make an impact on aquifer

Conclusion

- High level modeling and analysis indicate aquifer recharge may be a feasible method of sustainable water recycling for HRSD
- Concept has potential to provide many environmental benefits
- Cost is not out of reach – already planning on over $2B for RWWMP
  - TMDL backstop over a $1B threat
- Timing may be right for a project of this complexity to succeed
- Complements “right sizing” of permits to increase ***sustainable*** safe yield of aquifer

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Next steps

- Model and quantify
  - Impact on saltwater intrusion
  - Impact on land subsidence
  - Safe yield
  - Spatial analysis and travel time to existing withdrawals
- Additional water treatment technology analysis and evaluation – pilot-scale
- Scope demonstration-scale project (1 MGD) – advanced treatment & aquifer injection
- Further evaluation of geochemistry
- Develop more detailed costs for each plant
- Engage stakeholders

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Key Dates

- Current administration winds down late 2017
- EVGWAC report due late 2017
- RWWMP due to EPA/DEQ Oct 2017
- Draft Phase III WIP due Jun 2017, final due Dec 2017

Timeline

- Finalize Phase 2 scope – Dec 1, 2015
- Complete Phase 2 by end of 2016
- Room scale pilot projects – evaluation early 2017
- 2017
  - Endorsement from DEQ/VDH to move forward
  - EVGWAC recommends our project
  - EPA agrees RWWMP includes reopener for integrated plan
  - Phase 3 WIP includes this project to achieve TMDL goals
- 2018
  - 1 MGD Demonstration pilot (2 year study)
- 2020
  - EPA/DEQ/VDH formally approves CTC for SWR
- 2020 to 2030 (accelerated to 2025 based on Phase 3 WIP needs)
  - Construction through phased implementation
- 2030 Fully operational
  - 120 MGD of clean water injected into the aquifer

Questions?

*Future generations will inherit clean waterways and **be able to keep them clean**.*